This is the "Imagery Requirements" section of the Space Segment Requirements Document.

This draft version does not contain information pertaining to thermal imaging capability. Thermal imaging requirements will be posted at a later date.

Version March 14, 2006

1.0 Introduction to imagery requirements section

This section establishes the requirements for image characteristics and image quality to be provided by the space segment. This section also describes the requirements for image correction that are necessary in order to verify space segment performance.

2.0 Collect all data required to meet imagery requirements

The space segment shall acquire and transmit LDCM sensor and ancillary data that meets the requirements of this document.

The full telemetry data of the observatory shall be acquired, stored and transmitted to the ground where the appropriate subset of telemetry shall serve as input into algorithms developed for requirements verification and image-product generation. The ancillary data shall be converted into engineering units when applicable to facilitate their later use.

3.0 Data Processing Algorithms

The data processing algorithms, described in the following sections, define the maximum set of ground processing operations that may be used to make corrections to the LDCM data, estimate and correct systematic errors in the LDCM data, and use government-provided support data to correct residual errors in the LDCM data so that the resulting corrected LDCM data meet the imagery requirements of sections 6 and 7.

3.1 Radiometric Correction Algorithms
The radiometric correction algorithms shall correct the raw detector sample data contained in the LDCM data so that the radiometrically corrected LDCM data meet the radiometric performance requirements in sections 6.1, 6.2.3 and 6.5.

3.1.1 Detector Bias Determination
The detector bias determination algorithm shall calculate the appropriate bias level for subtraction from each detector in the subsequent conversion to reflectance or radiance, using historical bias data and/or bias trends, focal plane temperatures, temperature sensitivity coefficients, simultaneous dark pixel data, and/or pre and post interval dark image data as necessary.

3.1.1.1 Detector Bias Determination Algorithm Restrictions
The detector bias determination algorithm shall be consistent with a global data acquisition strategy, i.e., it shall not require dark image data acquired immediately before or after each Earth scene. An Earth image acquisition may be up to 30 minutes removed from a dark acquisition.

3.1.2 Conversion to Radiance
The conversion to radiance algorithm shall take the raw output of each detector in digital numbers and convert it to spectral radiance (W/m^2-sr-μm) using the detector-by-

detector bias levels from 3.1.1, and previously derived absolute and relative gain coefficients.

3.1.2.2 Conversion to Radiance Algorithm Restrictions
The conversion to radiance algorithm shall not rely on the content of the specific scene being corrected to determine the gain corrections.

3.1.3 Conversion to Reflectance
The conversion to reflectance algorithm shall take the raw output of each detector in digital number and convert it to TOA reflectance (fractional) using the detector-by-detector bias levels from 3.1.1, and previously derived absolute and relative gain coefficients.

3.1.3.1 Conversion to Reflectance Algorithm Restrictions
The conversion to reflectance algorithm may not rely on the content of the specific scene being corrected to determine the gain corrections.

3.1.4 Inoperable Pixel Replacement
The inoperable pixel replacement algorithm shall replace the responses from pixels failing to meet the requirements for operability with values estimated based on the surrounding pixels.

3.1.4.1 Inoperable Pixel Replacement Methods
The inoperable pixel replacement algorithm shall provide selectable replacement methods including, but not limited to:

3.1.4.1.a Nearest-neighbor replacement.

3.1.4.1.b Linear interpolation replacement.

3.2 Geometric Correction Algorithms
The geometric correction algorithms shall register radiometrically corrected LDCM data to an absolute Earth coordinate reference system so that the resulting geometrically corrected LDCM data meet the geometric and geolocation performance requirements in section 7.

3.2.1 Ancillary Data Preprocessing
The ancillary data preprocessing algorithm shall operate on the LDCM ancillary data to detect and correct erroneous data, perform units rescaling and coordinate system conversions, and apply calibration corrections (e.g., clock correction, response/transfer function compensation, temperature sensitivity compensation). The resulting corrected LDCM ancillary data are used by subsequent geometric correction algorithms. Auxiliary calibration parameters, quality thresholds, and other reference data sets may be used in this process.

3.2.1.1 Ancillary Data Preprocessing Algorithm Restrictions

All input data (e.g., definitive ephemeris) required by the ancillary data preprocessing algorithm shall be available within 12 hours of LDCM data acquisition.

3.2.2 Line-of-Sight (LOS) Model Creation
The LOS model creation algorithm shall use preprocessed ancillary data in conjunction with auxiliary calibration parameters to construct a model that relates each LDCM detector line-of-sight to an absolute Earth-referenced coordinate system, such as Earth Centered Inertial of Epoch J2000, as a function of time.

3.2.2.1 LOS Model Creation Algorithm Restrictions
The LOS model creation algorithm shall not use image-derived measurements to improve accuracy.

3.2.3 Line-of-Sight Projection
The LOS projection algorithm shall use the LDCM LOS model in conjunction with the WGS84, G873 or current version, Earth model to intersect each detector line-of-sight, as a function of time, with the Earth's surface, as defined in the following sections.

3.2.3.1 LOS Projection to the Earth Ellipsoid Surface
The LOS intersection algorithm shall provide the capability to intersect each detector line-of-sight, as a function of time, with the WGS84 Earth ellipsoid surface.

3.2.3.2 LOS Projection to the Terrain Surface
The LOS intersection algorithm shall provide the capability to intersect each detector line-of-sight, as a function of time, with the Earth's topographic surface as defined by government-furnished digital elevation data accurate to 12 meters (90% linear error).

3.2.3.3 LOS Projection Algorithm Restrictions
The LOS intersection algorithm shall not use image-derived measurements to improve accuracy.

3.2.4 Line-of-Sight Model Correction
The LOS model correction algorithm shall use measurements of government-provided ground control points in the radiometrically corrected LDCM imagery to correct residual systematic errors in the LOS model constructed using the LDCM ancillary and calibration data, as described in section 3.2.2. The government-provided ground control points will be accurate to 3 meters (90% circular error) horizontally and 12 meters (90% linear error) vertically, with 5 or more points distributed in the along- and cross-track directions across the WRS-2 scene area.

3.2.4.1 LOS Model Correction Algorithm Restrictions
The LOS model correction algorithm shall not use ground reference data beyond that provided by the government.

3.2.5 Image Resampling

The image resampling algorithm shall use the cubic convolution algorithm to interpolate at-sensor radiance values for Earth-referenced sample points from the radiometrically corrected LDCM image data by using the line-of-sight projection algorithm of 3.2.3 to geometrically remap the radiometrically corrected detector samples from 3.1 to an Earth-referenced map projection coordinate system.

3.2.5.1 Image Resampling Algorithm Performance
The image resampling algorithm shall be able to create a geometrically corrected LDCM image (all spectral bands) for a WRS-2 scene-sized area, at the nominal ground sample distance for each spectral band, using one commercially available off-the-shelf workstation, in 1 hour or less.

4.0 Spectral Bands
The Space Segment shall have spectral bands per the requirements in this section.

4.1 Spectral Band Widths

4.1.1 Full-Width-Half-Maximum Points
The Full-Width-Half-Maximum (FWHM) points of the relative spectral radiance response curve for each spectral band shall fall within the range of the minimum 50% lower band edge and the maximum 50% upper band edge as listed in Table 4-1.

4.1.2 Center Wavelength
The center wavelength listed in Table 4-1 for each spectral band shall be located (within the associated tolerance listed in Table 4-1) halfway between the FWHM points of the actual relative spectral radiance response curve for each spectral band.

Table 0-1 Spectral Bands and Band Widths

#	Band	Center Wavelength (nm)	Center Wavelength Tolerance (±nm)	Minimum Lower Band Edge (nm)	Maximum Upper Band Edge (nm)
1	Coastal Aerosol	443	2	433	453
2	Blue	482	5	450	515
3	Green	562	5	525	600
4	Red	655	5	630	680
5	NIR	865	5	845	885
6	SWIR 1	1610	10	1560	1660
7	SWIR 2*	2200	10	2100	2300
8	Panchromatic **	590	10	500	680
9	Cirrus	1375	5	1360	1390

*   Minimum bandwidth is 180 nm for band 7
** Minimum bandwidth is 160 nm for the panchromatic band

4.2 Spectral Band Shape

4.2.1 Spectral Flatness

4.2.1.1 Flatness Between Band Edges

The relative spectral radiance response between the lower band edge (lowest wavelength with 0.5 of peak relative response) and the upper band edge (highest wavelength with 0.5 of peak relative response) shall have the following properties:

4.2.1.1.1 Average Response

The average relative spectral radiance response shall be greater than 0.8.

4.2.1.1.2 Minimum Response

No relative spectral radiance response shall be below 0.4.

4.2.1.2 Flatness Between 80% relative response points

The relative spectral radiance response between the minimum wavelength with a 0.8 relative response point and the maximum wavelength with a 0.8 relative response point shall always exceed 0.7.

4.2.2 Out of Band Response

4.2.2.1 Beyond 1% Relative Response

The ratio of the integrated relative spectral radiance response beyond the 1% relative response points to the integrated response between the 1% relative response points shall be less than 2%.

The 1% relative response points are the points closest to the center wavelength where the relative response first drops to 1% of the peak relative response on each side of the center wavelength. The integrated responses will be weighted by the solar TOA irradiance. Electrical crosstalk is not included within this requirement.

4.2.2.2 Response at Outer Wavelengths

4.2.2.2.1 VNIR and Cirrus

For any of the VNIR and Cirrus bands, the value of the out of band relative spectral response at wavelengths which are lower than the lower band edge of the FWHM point minus 50 nm and the at wavelengths which are higher than the higher band edge of the FWHM point plus 50 nm shall not exceed 0.1% (of the normalized peak response). Electrical crosstalk is not included within this requirement.

4.2.2.2.2 SWIR

Similarly for the two SWIR and panchromatic bands the value of the out of band relative spectral response at wavelengths which are lower than the lower band edge of the FWHM point minus 100 nm and the wavelengths which are higher than the higher band edge of the FWHM point plus 100 nm shall not exceed 0.1% (of the normalized peak response). Electrical crosstalk is not included within this requirement.

4.3 Edge Slope

4.3.1 Wavelength Intervals – Case 1

The wavelength interval between the first 5% and the first 50% of peak relative response and the last 50% and the last 5% of peak relative response ranges shall not exceed the values in Table 4-2.

4.3.2 Wavelength Intervals – Case 2

The wavelength interval between the 1% relative response points and the corresponding 50% relative response band edge shall not exceed the values in Table 4-2.

Table 0-2 Edge Slope Intervals for SSI Bands

#	Band	Lower Edge Slope Interval 1% to 50%* (nm)	Lower Edge Slope Interval 5% to 50%* (nm)	Upper Edge Slope Interval 50% to 5%* (nm)	Upper Edge Slope Interval 50% to 1%* (nm)
1	Coastal Aerosol	15	10	10	15
2	Blue	25	20	20	25
3	Green	25	20	20	25
4	Red	25	20	15	20
5	NIR	25	20	15	20
6	SWIR 1	40	30	30	40
7	SWIR 2	50	40	40	50
8	Panchromatic	50	40	40	50
9	Cirrus	15	10	10	15

* % of peak relative spectral response for the band

4.4 Spectral Uniformity
Within a band, all detector bandwidths shall be within ±3% of the mean bandwidth. Additionally see Section 6.2.3.

4.5 Spectral Stability
Band center wavelengths and band edges shall not change by more ± 2 nm over the life of the mission.

4.6 Spectral Band Simultaneity
For any point within a single WRS-2 scene, the Space Segment shall acquire data for all spectral bands within a (1.5)-second period.

5.0 Spatial Data Sampling Intervals
5.1 Ground Sample Distance

5.1.1 Multispectral Ground Sample Distance

5.1.1.1 Pixel-to-Pixel Increment

Space Segment sensor data shall provide a pixel-to-pixel increment, in the in-track and cross-track directions, equivalent to a Ground Sampling Distance (GSD) less than or equal to 30 m across the WRS-2 scene for Spectral Bands 1, 2, 3, 4, 5, 6, 7 and 9.

5.1.2 Panchromatic Band

Space Segment sensor data shall provide a single panchromatic band with a pixel-to-pixel increment, in the in-track and cross-track directions, equivalent to a GSD less than or equal to 15 m across the WRS-2 scene.

5.2 Edge Response

The mean relative edge response slope in the in-track and cross-track directions (mean of slope between 40%-60%) for sensor data shall conform to the criteria described in the following subsections.

Note: Table 5-1 lists the bands, their maximum allowable GSD, and the minimal edge slope. The edge response, in the context below, is the normalized response of the imaging system to an edge. That is, the edge response is normalized so that the mean minimum edge response is set to zero and the mean maximum response is set to 100%.

Table 5-1 GSD / Minimum Slope Specification

#	Band	Maximum GSD	Minimum Slope
1	Coastal Aerosol	30 m	.027 / m
2	Blue	30 m	.027 / m
3	Green	30 m	.027 / m
4	Red	30 m	.027 / m
5	NIR	30 m	.027 / m
6	SWIR 1	30 m	.027 / m
7	SWIR 2	30 m	.027 / m
8	Panchromatic	15m	.054 / m
9	Cirrus	30m	.027 / m

5.2.1 Standard Band Edge Response Slope

The mean relative edge response slope for Spectral Bands 1, 2, 3, 4, 5, 6, 7 and 9 (<=30 m GSD) shall exceed 0.027/meter for space segment sensor data across the entire Field-of-View per Table 5-1.

5.2.2 Panchromatic Band Edge Response Slope

The mean relative edge response slope for the panchromatic band, spectral band 8 (<=15m GSD), shall exceed .054 / meter for Space Segment sensor data across the entire Field-of-View per Table 5-1

5.2.3 Edge Response Overshoot

The overshoot of any edge response for all bands shall not exceed 5% for space segment sensor data.

5.2.4 Edge Response Uniformity

The mean relative edge response slope shall not vary by more than 10% (maximum deviation from the band average) in any band across the Field-of-View and by not more than 20% (maximum deviation from the multi-band average) between Spectral Bands 1,2,3,4, 5, 6, 7, and 9 for space segment sensor data.

5.3 Aliasing
The product of the mean relative edge response slope and the GSD provided by Space Segment sensor data shall be less than 1.0 for both the in-track and cross track directions.

5.4 Stray Light Rejection and Internal Scattering
The effectiveness of the rejection of stray light and internal light scattering in the Space Segment sensor data is defined in terms of a scene with the following characteristics: The Space Segment sensor data are collected from a circular region having a radius = 0.25 degrees and having a uniform target radiance = LT . That target region is surrounded by an annular region having an inner radius = 0.25 degrees and an outer radius = 25 degrees and having a uniform background radiance = LB.

When LB = L T, the Space Segment instrument radiance measured at the center of the target region has a nominal value = LT. When LB is not equal to LT, the magnitude of the change in measured Space Segment instrument radiance at the center of the target region shall be less than 0.004 times the magnitude of the difference between LB and LT. This requirement applies to all spectral bands for the duration of the nominal Space Segment instrument mission for target and background radiance levels ranging from a minimum of zero to a maximum of LMax, such that LT - L B ranges from a minimum of - LMax to a maximum of L Max.

5.5 Ghosting
An extended object with a maximum diameter equivalent to an enclosing diameter of up to half the WRS-2 scene extent and, at a radiance level just below the detectors saturation level, anywhere in the Space Segment instrument telescope full FOV, shall not produce a significant (as described below) ghost image anywhere in the active detectors area of the focal-plane. This absence of a ghost image requirement applies to all spectral bands across the entire focal plane.

A ghost image is a secondary image of an object, which appears as either an attenuated rendition of the original object or a blurred and attenuated version of the original object. A ghost also has a constant displacement vector from the original image. A significant ghost is defined as an image artifact when its peak signal after background level subtraction and radiometric calibration is above 2% of the typical radiance (Ltyp) for that band. This restriction is intended to prevent ghosting from significantly affecting the radiometric errors during normal operations.

6.0 Radiometry
6.1 Absolute Radiometric Uncertainty
The Space Segment instrument absolute radiometric uncertainty requirements are given in Table 6-1 for the range of Ltypical to 0.9 Lmax (Table 6-2) with all uncertainties established relative to National Institute for Standards and Technology (NIST) standards. At any other radiance across the range of 0.3 Ltypical to Ltypical the absolute uncertainty shall not exceed the values in Table 6-1 by more than 0.5%. This requirement applies to

extended, spatially uniform, unpolarized targets with a known spectral shape. Uncertainty estimates include the NIST standard uncertainties.

Table 6-1 Absolute Radiometric Uncertainty Requirements

Parameter	Requirement (1-sigma)
Radiance	5%
Top of Atmosphere (TOA) Reflectance	3% of actual TOA

Table 6-2 Radiance Levels for Signal-to-Noise Ratio (SNR) Requirements and Saturation Radiances

#	Band	Radiance Level for SNR, L (W/m^2 sr μm)		Saturation Radiances, L_{Max} (W/m^2 sr μm)
		Typical, $L_{Typical}$	High, L_{high}	Requirement
1	Coastal Aerosol	40	190	555
2	Blue	40	190	581
3	Green	30	194	544
4	Red	22	150	462
5	NIR	14	150	281
6	SWIR 1	4.0	32	71.3
7	SWIR 2	1.7	11	24.3
8	Panchromatic	23	156	515
9	Cirrus	6.0	N/A	88.5

6.2 Radiometric Signal to Noise and Uniformity

6.2.1 Pixel Signal-to-Noise Ratios (SNRs)

The median SNRs required for all Space Segment sensor data for each spectral band shall be as listed in Table 6-3.

a.) 50% of all detectors for each band shall meet or exceed these SNR values.

b.) Any detector below 80% of these values shall be considered out-of-spec per paragraph 6.7.3.

Table 6-3 SNR Requirements

#	Band	SNR Requirements	
		At $L_{Typical}$*	At L_{High}*
1	Coastal Aerosol	130	290
2	Blue	130	360
3	Green	100	390
4	Red	90	340
5	NIR	90	460
6	SWIR 1	100	540
7	SWIR 2	100	510
8	Panchromatic	80	230
9	Cirrus	50	N/A

* - see table 6-2 for definition of Ltypical and Lhigh

6.2.2 Space Segment Sensor Data Quantization

a. Space Segment sensor data shall be quantized to 12 bits.

b. Space Segment sensor data SNR performance shall not be quantization noise limited at Ltypical and above, i.e., system noise is greater than or equal to 0.5 Digital Number, unless meeting this requirement would force greater than 12 bit quantization.

6.2.3 Pixel-to-Pixel Uniformity

6.2.3.1 Full Field of View

For a spatially uniform source above 2*Ltypical, the standard deviation of the radiometrically corrected, per paragraph 3.1.2, values across all pixels within a line of Space Segment sensor data within a band shall not exceed 0.25% of the average radiance. Temporal (within column) noise may be averaged to verify compliance with this specification.

6.2.3.2 Banding

a.) For a spatially uniform source above 2*Ltypical , the root mean square of the deviation from the average radiance across the full line for any 100 contiguous pixels within a line of radiometrically corrected, per paragraph 3.1.2, values. Space Segment sensor data within a band shall not exceed 0.5% of that average radiance. Temporal (within column) noise may be averaged to verify compliance with this specification.

Rationale: This spec is intended to control locally strong variations in the pixel-to-pixel uniformity (PPU) that would have little impact on the full FOV PPU in 6.2.3.1, but never less would be visible in a large uniform scene. For example, situations such as: residual vignetting, optical angular effects, and strong angular variations in radiation from the calibration sources may cause the effects that this specification seeks to address.

This banding parameter, $Band_{rms}$ shall be calculated as:

$$Band_{rms} = \sqrt{\sum_{i=n}^{n+99} (L_i - \overline{L}')^2 / 100}$$

where:

n is the number of each detector in a line of data

L_i is the individual calibrated detector response in radiance units

$\overline{L}'$ is the average calibrated detector response across the full line in radiance units

b.) For a uniform source above 2*Ltypical , the standard deviation of the radiometrically corrected, per 3.1.2 values across any 100 contiguous pixels within a line of Space segment sensor data within a band shall not exceed 0.25% of the average radiance across the full line. Temporal (within column) noise may be averaged to verify compliance with this specification. The average radiance across the line (FOV) is used here merely as a reference for deriving the magnitude of the 0.25%. The mean in the standard deviation calculation is, by definition, the mean of the 100 pixel sample set and not the entire FOV mean. Rationale: This specification is intended to control discontinuities in the PPU such as might arise when going from one SCA to another in an ALI-like sensor design or block pattern effects that might arise in the detector array mask processing.

This banding parameter, $Band_{stddev}$ shall be calculated as:

$$Band_{stddev} = \sqrt{\sum_{i=n}^{n+99} (L_i - \overline{L})^2 / 100}$$

where:

n is the number of each detector in a line of data

L_i is the individual calibrated detector response in radiance units

$\overline{L}$ is the average calibrated detector response across the 100 pixel sample set in radiance units

$$\overline{L} = \sum_{i=n}^{n+99} L_i / 100$$

6.2.3.3 Streaking

For a spatially uniform source above 2*Ltypical, the maximum value of the streaking parameter within a line of radiometrically corrected, per 3.1.2, Space Segment sensor data shall not exceed 0.005 for bands 1-7 and 9 or 0.01 for the panchromatic band. Temporal (within column) noise may be averaged to verify compliance with this specification.

The streaking parameter is defined by the following equation:

$$S_i = \left| L_i - \frac{1}{2}(L_{i-1} + L_{i+1}) \right| / L_i$$

 where:

L i is the calibrated radiance value measured for a pixel at an input radiance level;

 Li-1 and Li+1 are similarly defined for the (i−1)th and (i+1)th pixels.

Note: These requirements (6.2.3) apply for target radiances with spectral characteristics as follows: the spectral radiance from bare soil as observed through a dry atmosphere (excluding band 9), spectral radiance proportional to the TOA solar irradiance, and spectral radiance from a dense vegetation target as observed through a moist atmosphere (excluding band 9) as given in "Top of Atmosphere Radiance Values, MODTRAN 4 Model" table values, which is also depicted and imbedded as a spreadsheet in Figure 6-1. The target radiances are all determined using the same gain calibration coefficients.

6.2.3.4 Temporal stability of pixel to pixel uniformity

The requirements of section 6.2.3.1- 6.2.3.3 shall be met for any 7-day period using the same gain calibration coefficients.
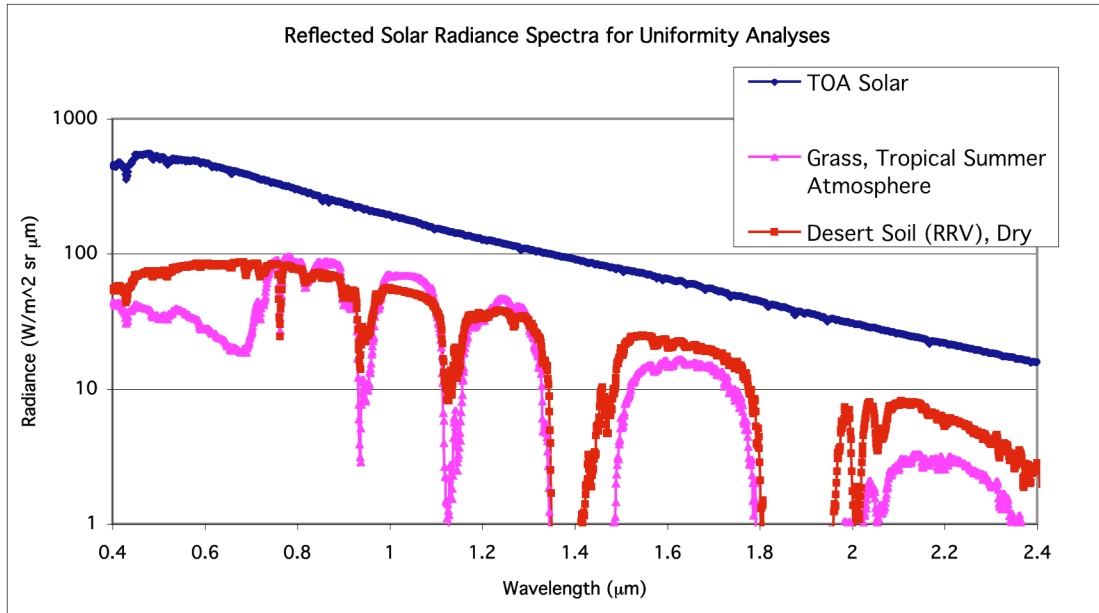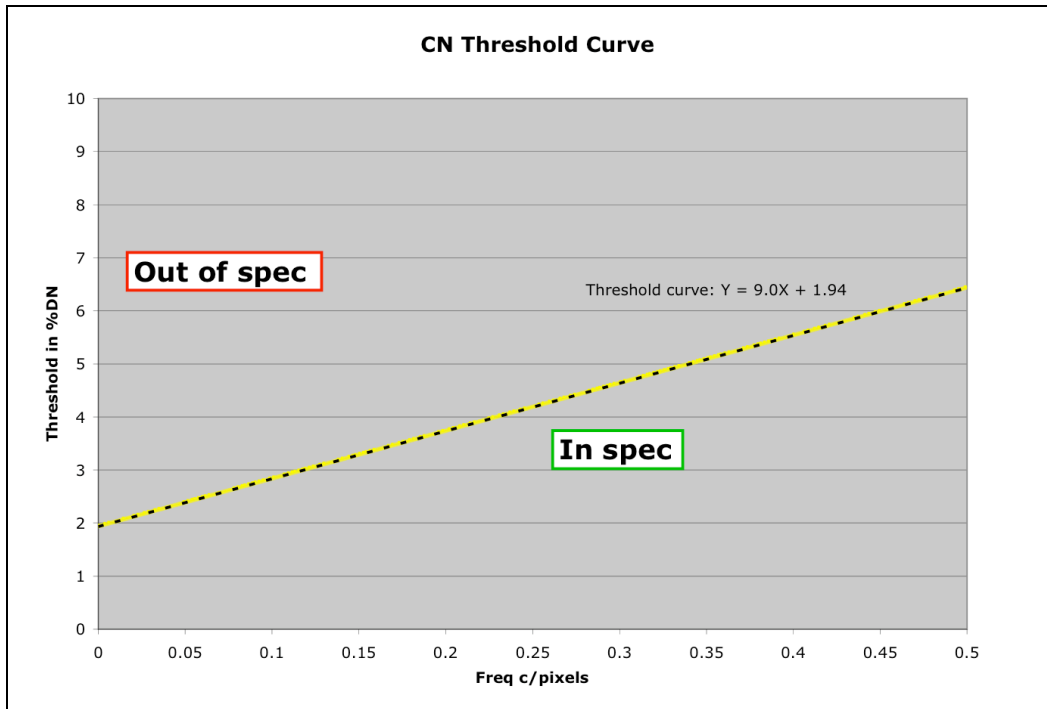
Figure 6-1 MODTRAN 4 Model Table Values

6.2.4 Coherent Noise

Any uniform scene or dark image in any band acquired by the Space Segment instrument, after radiometric calibration, shall not contain coherent noise (CN) components of any frequency (f, cycles/pixel), with relative percentage amplitude DN%, that is higher than the DN%max level denoted by the following formula: DN%max(f)= 9.0 f+1.9. Where the DN% is given by the ratio of the individual CN component amplitude to the overall impulse-feature free Peak-to-Valley (i.e. Peak-to-Valley of the average scene background excluding any impulse noise of very high or very low pixels), and the individual CN component amplitude is the amplitude of the wave pattern generated (for example in the model of a sine wave it will be the amplitude of a sine wave defined as Asin(b+phase). This coherent noise components restriction applies to all spectral bands in the fully populated FPA, from the SCA scale shortest acquisition image to the Full FPA scale WRS-2 scene acquisition time.

CN Threshold Curve

Threshold curve: Y = 9.0X + 1.94

Out of spec

In spec

Threshold in %DN

Freq c/pixels

Figure 6-2 Coherent Noise Threshold Curve

Definition:
DN% = (Amplitude of Coherent component) / (impulse feature free Dynamic Range in the image)*100%

6.3 Saturation Radiances
The Space Segment instrument shall detect, without saturating, signals up to the Lmax as shown in Table 6-2. Note**:** For bands 1-8, this corresponds to the radiance reflected off of a Lambertian target of 100% reflectance illuminated by the sun at a solar zenith angle of 22.5°.

6.4 Polarization Sensitivity
The Space segment instrument polarization sensitivity, as defined by the linear Polarization Factor (PF), shall be less than 0.05. Note, PF = (Imax-Imin)/ (Imax+Imin).

6.5 Radiometric Stability
a.) Over any time up to 16 days, for each detector, after radiometric correction per 3.1.2, with one set of gain coefficients that were determined prior to the 16 day period, the Space Segment sensor data for radiometrically constant targets with radiances greater than or equal to L-typical shall not vary by more than plus or minus (95% or 2-sigma confidence interval) the sum of 1% of measured radiance and the equivalent radiance of 1 bit. Detectors failing this specification are considered out-of-specification and are subject to the limitations of paragraph 6.7.3.

b.) Over any time period between 16 days and 5 years, for each detector, after radiometric correction, per 3.1.2, the Space Segment sensor data for radiometrically constant targets with radiances greater than or equal to Ltypical shall not vary by more than plus or minus (95% or 2-sigma confidence interval) the sum of 2% of target radiance and the equivalent radiance of 1 bit. Detectors failing this specification are considered out-of-specification and are subject to the limitations of paragraph 6.7.3.

c.) Over any 30 second period, for each detector, the Space Segment instrument data for radiometrically constant targets with radiances greater than or equal to L-typical shall not vary by more than plus or minus (95% or 2-sigma confidence interval) the sum of 0.5% of target radiance and the equivalent radiance of 1 bit. Detectors failing this specification are considered out-of-specification and are subject to the limitations of paragraph 6.7.3.

6.6 Image Artifacts

6.6.1 Bright Target Recovery

The Space Segment sensor data shall be such that for an image pixel that has been exposed to a radiance level of less than or equal to 1.5 times that of the saturation radiances (Table 6-2), the pixels outside the 7 x 7 region around that pixel are not altered by more than 1% of their radiance for bands 1-7 and 9 and 2% for the panchromatic band for radiances at or above Ltypical.

6.6.2 Pixel-to-Pixel Crosstalk

The Space Segment sensor data shall be such that the electrical crosstalk-induced artifacts in pixels caused by regions of pixels having radiance levels less than the saturation level and which are more than ten pixels away shall not exceed 1% of the affected pixels' radiances at or above Ltypical, after radiometric correction.

6.7 Dead, Inoperable, and Out-of-Spec Pixels

6.7.1 Dead or Inoperable Pixels

Less than 0.1% of all Space Segment instrument image pixels in any WRS-2 scene shall be dead or inoperable.

Note: Dead or inoperable pixels may be removed from any performance averages and standard deviations for determining compliance to performance specifications.

6.7.2 Dead or Inoperable Pixels per Band

Less than 0.2% of the Space Segment instrument image pixels in any spectral band in any WRS-2 scene shall be dead or inoperable.

6.7.3 Adjacent Dead or Inoperable Pixels

There shall be no adjacent dead or inoperable instrument image pixels in any WRS-2 scene.

6.7.4 Out-of-Spec Pixels

Less than 0.25% of the operable Space Segment instrument image pixels in any spectral band in any WRS-2 scene shall fail to meet one or more performance requirements. Note: Out-of-spec pixels may be removed from any performance averages and standard deviations for determining compliance to performance specifications.

7.0 LDCM Geometric Precision, Geolocation, and Cartographic Registration

The following sections detail the LDCM image geometric accuracy requirements that must be achieved when the correction algorithms provided in accordance with section 3.0 of this specification are applied to LDCM Space Segment sensor and ancillary data (LDCM data). The specific correction algorithms that apply to each geometric imagery requirement are shown in table 7-1.

Table 7-1 Image Requirement to Processing Algorithm Verification Mapping

	3.1 Radiometric Correction	3.2.1 Ancillary Data Processing	3.2.2 Line-of-Sight (LOS) Model Creation	3.2.3.1 LOS Projection to WGS84 Ellipsoid Surface	3.2.4 LOS Model Precision Correction	3.2.3.2 LOS Projection to Terrain Surface	3.2.5 Image Resampling
7.1 Band Registration Accuracy	X	X	X	X	X	X	X
7.2 Image Registration Accuracy	X	X	X	X	X	X	X
7.3.1 Relative Geodetic Accuracy	X	X	X	X			X
7.3.2 Absolute Geodetic Accuracy	X	X	X	X			X
7.4 Geometric Accuracy	X	X	X	X	X	X	X

7.1 Band-to-Band Registration Accuracy

Corresponding pixels from the spectral bands in LDCM data that have been geometrically corrected, including compensation for the effects of terrain relief shall be co-registered with an uncertainty of 4.5 meters or less in the line and sample directions at the 90% confidence level.

7.2 Image-to-Image Registration Accuracy

Two LDCM data sets of the same area, acquired on different dates, that have been geometrically corrected, including compensation for the effects of terrain relief, shall be capable of being co-registered by a lateral (line and/or sample) shift with no rotation or other distortion, with an uncertainty less than or equal to 12 meters, in the line and sample directions at the 90% confidence level when image-to-image correlation is applied to data from the same spectral band. This requirement applies to data from all spectral bands except the cirrus band (band 9).

7.3 Geodetic Accuracy

Geometrically corrected LDCM data shall exhibit the geolocation accuracy defined in the following sections.

7.3.1 Absolute Geodetic Accuracy

The pixels for targets at the Earth's topographic surface in geometrically corrected LDCM data shall be located relative to the WGS84 geodetic reference system, G873 or current version, with an uncertainty less than or equal to 65 meters (90% circular error), excluding terrain effects. This specification applies to the horizontal error of ground control points measured in the processed image, after compensation for control point height.

7.3.2 Relative Geodetic Accuracy

The pixels for targets at the Earth's topographic surface in geometrically corrected LDCM data shall be located relative to the WGS84 geodetic reference system, G873 or current version, with an uncertainty less than or equal to 25 meters (90% circular error), excluding terrain effects, over a WRS-2 scene, after the removal of constant offsets. This specification applies to the standard deviation of ground control points measured in the processed image, after compensation for control point height.

7.4 Geometric Accuracy

The pixels for targets at the Earth's topographic surface in LDCM data that have been geometrically corrected, including pointing refinement using ground control and terrain compensation using digital elevation data, shall be located relative to the WGS84 geodetic reference system, G873 or current version, with an uncertainty less than or equal to 12 meters (90% circular error), including compensation for terrain effects.